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Washington DC 20330-1690

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SUBJECT: Paper approval for: NPOESS VIIRS Day/Night Band (DNB)

Enclosed are the required ten (10) copies of the subject papers. This paper will be released at the IGARSS02 conference in June of '02. It was written by, and will be presented by employees of Raytheon Electronic Systems.

The program office has reviewed the information in the attached papers and found it appropriate for public disclosure without change.

Point of contact on this matter is Capt. Ken Speidel, NPOESS IPO/ADA at 301-427-2084 (Ext. 208).

Attachment: Presentation—10 copies

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NPOESS VIIRS Day/Night Band (DNB)

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The Problem: Daylight Is A Million Times Brighter Than Moonlight

- This range can occur in a single VIIRS scan
  - 3,000 km scan is distance from Los Angeles to Chicago
- Normal Sensors Cannot Cover This Brightness Ratio
- Very high local contrasts also occur
  - Sunlit, high-altitude clouds over dark ground at terminator
  - Cities, fires in dark night scenes
- Analysts require images with day/night difference corrected

NPOESS VIIRS Overview

- National Polar Orbiting Environmental Satellite System (NPOESS): 3 Satellites in 833-km, Sun-synchronous orbits
  - Continues DMSP, POESS, and EOS Missions
  - Payload = Up to 6 Sensors Including Visible/Infrared Imager Radiometer Suite (VIIRS)
- VIIRS configuration dictated by requirements other than Night Imaging
  - Sample Spacing < 0.5 km & Band-Band Registration >80% → Single Sensor
  - 27 data products → 22 Spectral Bands, 0.4μm < λ < 12μm → Reflective Optics
  - Daily Revisit → 3,000 km swath (112 deg field of view)→ Optomechanical Scanning
  - The above → 88 μsec sample time with 16 detectors/band

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DNB Requirements Summary

- Dynamic Range: 7.5e-5 ≤ L ≤ 500 W/m^2/sr/μm
  - Signal/Noise Ratio (SNR) @ Lmin ≥ 6
  - Lmin approx times dimmer than any other band radiance
  - No saturation from extreme contrasts
- Horizontal Spatial Resolution (HSR) ≤ 800 m
  - Defined as (0.5x spatial wavelength @ MTF = 0.5)
- (No requirement for registration to other bands)
- Operational Through South Atlantic Anomaly
- Lifetime on orbit >7 years
- Spectrum: Center 700 ±14nm, Width 400 ±20nm
  - Chosen to avoid atmospheric absorption & scattering
- Horizontal Sampling Interval (HSI) 742 meters ±5%, track & scan at all scan angles

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How Did We Include The DNB In The Main Sensor??

- Low light level requires adding signals from 400 samples
  - Noiselessly implemented in CCD as 2 stages of 250 TDI each
  - Scene image is scanned across 250 detectors & signals added
- Dynamic range of 5e6:1 covered by 3 separate gain stages on one CCD
  - Stage gains in ratios
  - For each pixel, word transmitted is from highest-gain stage that is not saturated
- Rotating Telescope scan system provides very effective stray light control, allows scanning field of view near sun
- Pixels of low light stages often impacted by energetic particles in South Atlantic
  - Readings from the two stages compared to detect impacts
  - If neither stage has been impacted, readings are averaged

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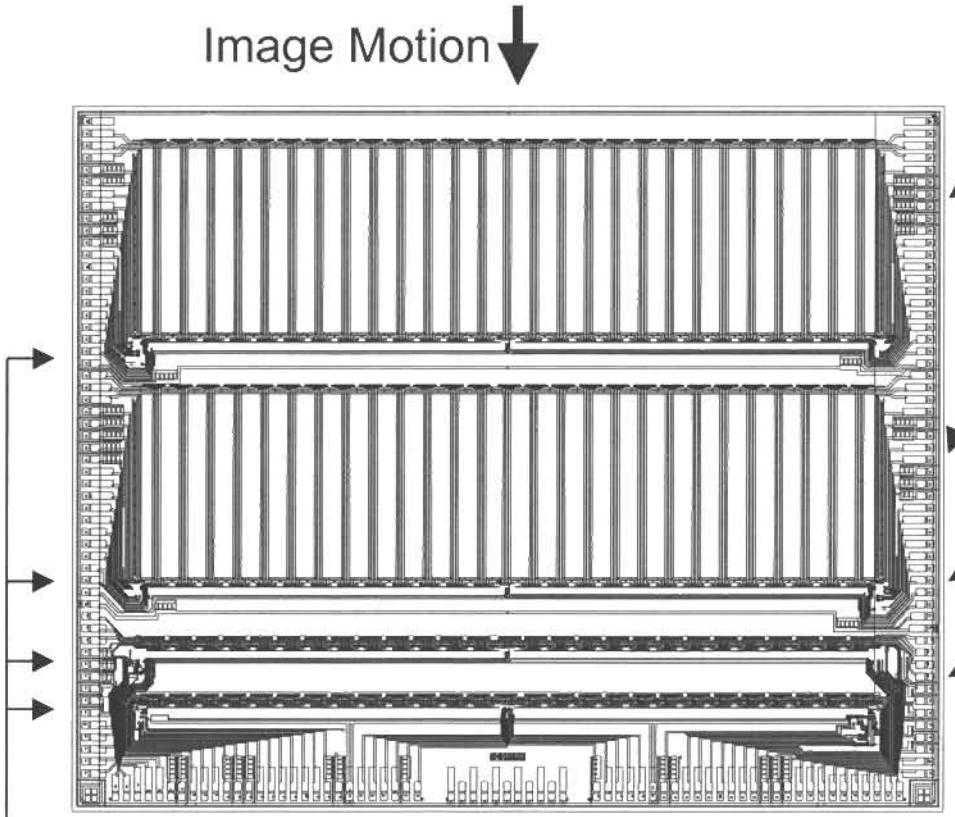
DNB Detector Is Multistage CCD



- Two identical high-gain stages allow correction of radiation impacts in data
  - 250 Dets In TDI
- One Intermediate-gain stage
  - 3 dets in TDI
- One Low-Gain Stage
  - No TDI
  - 35x N.D. Filter
- Operating temp. -20C
- Separate clocks to each range for graceful fault tolerance

- Eight analog outputs - 4 on each side of chip

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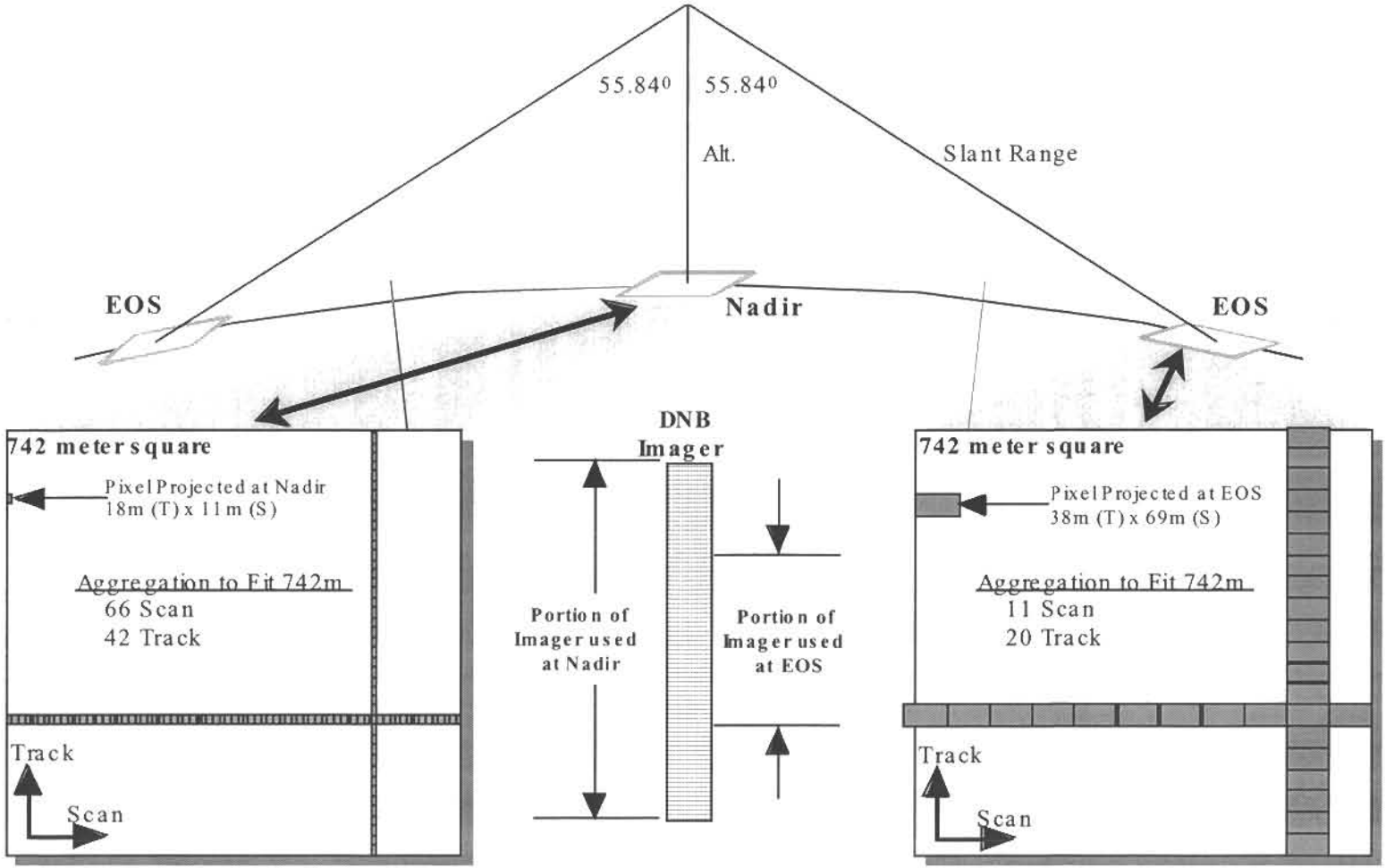
4-Stage, 3-Gain CCD With Extensive TDI (Time Delay Integration)

- Charge shifted at rate of optical image motion
  - Subpixel radiometric gain proportional to number of detectors in TDI
- Externally controlled variable aggregation gives near-constant HSI (742 x 742 meters ±5%)
  - Min = 11 Scan x 20 Track, Max = 66 Scan x 42 Track
  - Radiometric gain proportional to aggregation, so varies across scan
- Stage 1A & 1B for radiation impact correction
- Data from 4 Stages Merged by Electronics Module into 1 stream, with piecewise linear radiometric transfer function
- From known sun angle, software produces images showing reflectances of scene, rather than brightness

Raytheon Variable Aggregation Gives Near Constant Sample Spacing throughout Scan



Sensor cycles through 32 Aggregation Modes between EOS & Nadir

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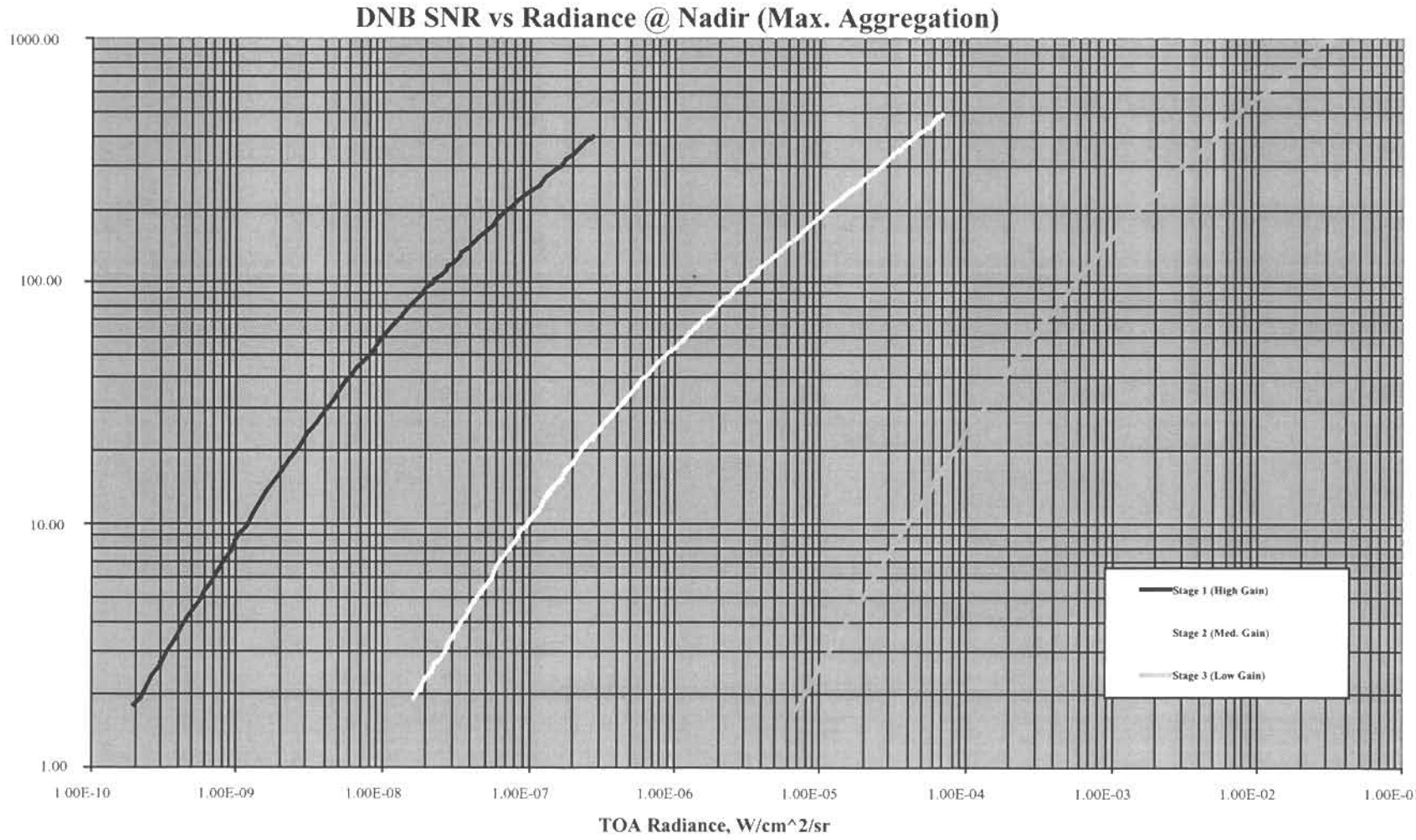
SNR vs. Radiance At Nadir



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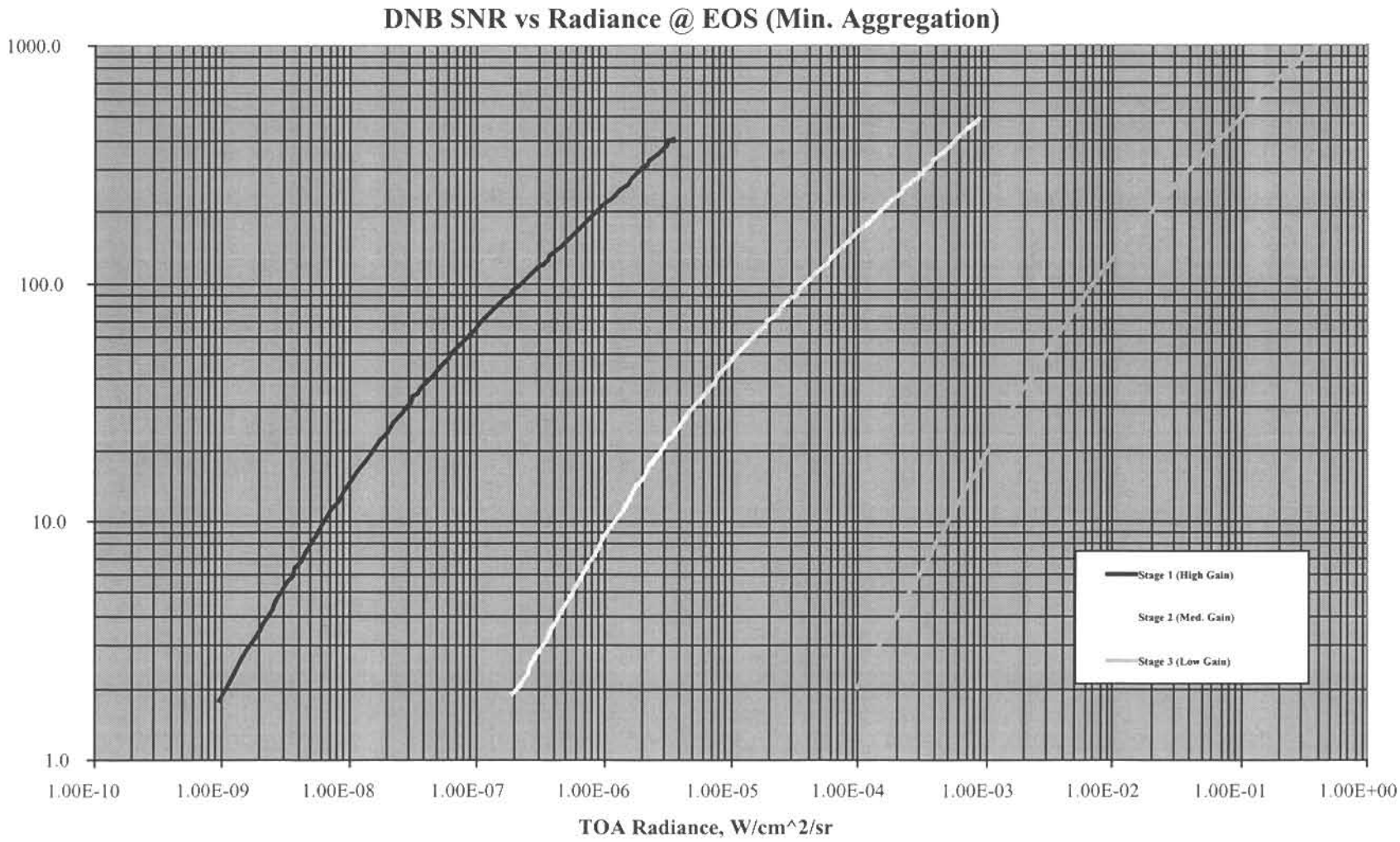
SNR vs. Radiance At EOS



DNB Performance Summary

- Total dynamic range = 44,000,000:1
- Extreme contrasts do not cause saturation
- MTF @ 2x742 m >0.5
- SNR @ Lmin @ EOS > 6; SNR @ Lmin @ nadir >30
- Sensor output is readily converted into "constant contrast" visible product
  - Contrast and gray scale values remain approximately constant over entire width of scan, minimizing apparent effect of day/night terminator